Institute for Empirical Research in Economics
University of Zurich

Working Paper Series
ISSN 1424-0459

Working Paper No. 60

"Did we Overestimate the Value of Health?"

Rafael Lalive

October 2000

Did we Overestimate the Value of Health?

Rafael Lalive, IEW, University of Zurich*

First version: September 1999

This version: October 2000

Abstract

Adam Smith's idea that wage differences reveal preferences for risk rests on firm theoretical foundations. This paper argues, however, that the standard approach to identify these differentials in practice may be flawed. Empirical practice usually identifies compensating wage differentials for risk by regressing individual wages on aggregate measures of risk, usually industry or occupation average risk. If jobs differ within industries or occupations, the "aggregate approach" may identify arbitrary compensating differentials for risk. In a dataset with precise information on job risk as well as aggregate risk, I demonstrate that using aggregate risk identifies wage differentials that are two to five times larger than wage differentials based on job risk information. This result is robust to controlling for time constant unobserved individual or job heterogeneity.

JEL classification: J17, J31

Keywords: value of life, value of health, compensating wage differentials, occupational illness

*I am indebted to Angelika Eymann, Ernst Fehr, Simon Gächter, Lorenz Götte, Dominique Lalive, Alois Stutzer, Josef Zweimüller, seminar participants at EEA 1999, and at German Economic Association 1999 for comments on earlier drafts of this paper. This research has been supported by the Austrian Central Bank's Jubilee Fund (#6819/2). Address: Blümlisalpstr. 10, CH-8006 Zürich, rlalive@iew.unizh.ch.

1 Introduction

"The reason for [the substantial differences in the estimates of the value of life] has not yet been resolved, but the crudeness of the risk measures available surely is an important cause."

– Sherwin Rosen (1986)

The theory of equalizing differences explains elegantly how trade in jobs with different amenities takes place. Workers choose risky jobs if their willingness to avoid the risk is less than the difference in wages between risky and not so risky jobs. Firms offer a risky job if protecting workers from risk is more costly than the wage differential. In equilibrium, wages adjust such that, both, the market for risky jobs and the market for not so risky jobs clear. The empirical prediction of the theory is that equilibrium wage differentials equal average preferences for risk.

While risk differentials are positive and significant in most empirical studies on risk differentials, the order of magnitude varies greatly. Estimated differentials go from about 1990 US$ 18,000 to US$ 90,000 (Viscusi, 1993). This paper argues that the differences in estimated risk differentials may be traced to the nature of the risk measure used.

Empirical tests of the theory rely critically on measures of job amenities. A recent survey by Viscusi (1993, p. 1925) notes that "the dominant approach followed in the literature is to rely upon some published measure of the risk level by occupation or industry, and then to match this risk variable to the worker in the sample using information provided by the respondent".[1]

Using aggregate risk to proxy for job risk is a valid approach if jobs are similar within occupations or industries. This approach may fail completely, however, if jobs are different within industries or occupations. For instance, suppose that risk does not vary across industries, but there are significant differences in job risk in at least one industry, say construction. "Iron workers" welding iron 300 feet above ground incur a much higher risk of injury or death than the average construction worker. Also, "iron workers" earn significantly more than the average construction worker. The aggregate approach assigns the same risk to iron workers as to the average construction worker in this economy thus discarding all information on compen-

[1] Thaler and Rosen (1976) pioneered this approach. Their study used occupation risk data provided by the Society of Actuaries to estimate the first market based estimates of the value of a statistical life.

sating differentials. If one uses a measure that reflects job risk more precisely, within industry variation in wages and risk in addition to aggregate variation is used to identify compensating differentials.

This paper combines a direct measure of job risk and a measure of aggregate risk with information on wages. The idea is that with two measures for job risk at hand, we can examine empirically, to what extent compensating differentials for risk differ when measured by the "aggregate approach" vs the "job risk approach". The main results are (i) job risk differs substantially within industries, (ii) the "aggregate approach" produces risk wage differentials that are two to five times larger than the "job risk approach", and (iii) this result is robust if we control for time constant unobserved individual or job heterogeneity.

Previous research expressed unease with the theory of equalizing differences because some differentials were not significant or other differentials did not have the sign expected from theory. Brown (1980) conducted an extensive study on compensating differentials based on time variation in job amenities and finds that even with high quality data some differentials are insignificant. Duncan and Holmlund (1983) test whether this unease vanishes if one uses worker self reported data on job quality; their findings are not thoroughly consistent with the theory either. Dickens and Katz (1987) and Krueger and Summers (1988) show that wage differences between industries can not be explained solely by differences in job amenities. Filer (1998) argues that compensating differentials based on aggregate occupation information do have "the right sign". The literature focusing on risks met with greater success often identifying positive and significant wage differentials. Critique of this literature focused first on the fact that labor markets are not perfectly competitive (Leigh, 1991 and Dorman, 1996). Second, Moore and Viscusi (1988) show that omitted variable bias may be important for risk differentials. Finally, Leigh (1995) and Dorman and Hagstrom (1998) worry about the difference in industry premia for risk vs occupation premia for risk.

Section 2 discusses in a simple example under what circumstances using aggregate data on risk may be detrimental for estimates of compensating differentials. Section 3 gives institutional details and some descriptive evidence on the dataset used. Section 4 presents the main result, and section 5 concludes.

2 When is aggregate risk a bad proxy for job risk?

This section discusses the conditions that may lead to biased estimates of compensating differentials for risk by the "aggregate procedure" based on a simple example. The example will illustrate that if jobs are heterogeneous within industries, a bias may result in standard hedonic wage regressions.

We start with the economy described in Viscusi (1993). Providing workplace safety is costly to firms. To maintain the same isoprofit curve, the firm must pay a lower wage rate to offset the cost of providing a safer work environment. The firm's wage offer curve will be an increasing function of risk. The offer curves of three distinct firms appear in Figure 1 as F_1, F_2, and F_3. For simplicity, each firm offers exactly one job.

Figure 1

Suppose that $U(w)$ denotes utility when healthy and $V(w)$ denotes utility when injured. The critical assumption for workers to demand compensating differentials for risk are that one would rather be healthy than not ($U(w) > V(w)$) and the marginal utility of income is positive ($U'(w), V'(w) > 0$). Workers will select the available wage-risk combination from the schedule WW that yields the maximum expected utility. For worker 1 in Figure 1 the optimal job risk is at the point where the worker's constant expected utility locus EU_1 is tangent to F_1, for worker 2 it is where EU_2 is tangent to F_2, and for worker 3 it is where EU_3 is tangent to F_3.

The slope of the EU curves can be readily verified. Wage-risk combinations that maintain a worker's constant expected utility level consist of the points that satisfy

$$Z(p, w) = (1 - p)U(w) + pV(w)$$

where p denotes risk. The wage-risk trade-off for a specific worker is given by

$$\frac{dw}{dp}|_{WW} = -\frac{Z_p}{Z_w} = \frac{U(w) - V(w)}{(1 - p)U'(w) + pV'(w)} > 0 \tag{1}$$

so the asking wage increases with the risk level p.

Equation (1) shows that it is not possible to estimate preferences for risk of a particular worker based on data that is usually used in value of health studies (cross-section micro data).

What can be learned, however, is *average* preferences for risk. The average preference for risky jobs of workers 1 and 2 is

$$\frac{dw}{dp}|_{F_{12}} = \frac{w_2 - w_1}{p_2 - p_1} \tag{2}$$

and the average preference for risk of workers 2 and 3 is

$$\frac{dw}{dp}|_{F_{23}} = \frac{w_3 - w_2}{p_3 - p_2} \tag{3}$$

Suppose that firms 1 and 3 belong to industry 1, and firm 2 belongs to industry 2. The compensating wage differential based on industry data is

$$\frac{dw}{dp}|_{I_{12}} = \frac{w_2 - .5(w_1 + w_3)}{p_2 - .5(p_1 + p_3)} \tag{4}$$

Two conditions are crucial for a bias in this economy: the shape of the hedonic wage function WW, and the shape of the risk distribution.[2] When the hedonic wage function WW is linear, we can distinguish two cases.

Case 1 *No variation in aggregate risk ($.5(p_1+p_3) = p_2$): In this case, the industry based wage differential (4) remains undefined even though the firm based wage differentials (2) and (3) are well defined.*

Case 2 *Some variation in aggregate risk ($.5(p_1+p_3) \neq p_2$): In this case, industry differentials (4) are the same as firm (or "true") differentials (2) and (3). The reason is that any ratio of wage and risk differences is constant with linear preferences for risk.*

Aggregate variation in risk is the only requirement for unbiased estimation with a linear hedonic wage function.

However, $\partial^2 w/\partial p^2|_{WW} = (V' - U')(U - V)/[(1-p)U' - pV']^2$ hence the hedonic wage function is linear if and only if the marginal utility of income does not depend on the health status of individuals ($U' = V'$). It is useful to distinguish first between concave and convex hedonic wage functions. Second, the risk ranking of industries is important. Four cases are distinguished

[2] We do not discuss cases with no overlap in job risks between industries 1 and 2. While this would yield different results, this case is harder to motivate from practice because there are low risk firms in high risk industries and high risk firms in low risk industries.

Case 3 ***Concave*** *hedonic wage function, industry 1 is* **low** *risk* ($.5(p_1 + p_3) < p_2$)*: The industry differential (4) is strictly larger than the large firm based differential (2). This is best shown graphically (Figure 2a). Figure 2a shows the largest firm 3 risk for which industry 1 risk is smaller than industry 2 risk. By moving firm 3 closer to firm 2 we trace out the locus of industry 1 risk satisfying the condition that industry 1 is the low risk industry. This locus is the fat ray starting halfway between* (w_1, p_1) *and* (w_2, p_2) *and ending on the vertical line from* (w_2, p_2) *to the abscissa. The industry risk differential is the slope from a point on the fat ray to* (w_2, p_2)*. This slope is always larger than the large firm risk differential (2).*

Figure 2

Case 4 ***Concave*** *hedonic wage function, industry 1 is* **high** *risk* ($.5(p_1 + p_3) > p_2$)*: The industry differential (4) is strictly smaller than the small firm based risk differential (3). It can take negative values (see Figure 2b; argument similar to Case 1).*

Case 5 ***Convex*** *hedonic wage function, industry 1 is* **low** *risk* ($.5(p_1+p_3) < p_2$)*: The industry differential (4) is strictly smaller than the small firm based risk differential (3). It can take negative values (see Figure 2c; argument similar to Case 1).*

Case 6 ***Convex*** *hedonic wage function, industry 1 is* **high** *risk* ($.5(p_1 + p_3) > p_2$)*: The industry differential (4) is strictly larger than the large firm based differential (2) (see Figure 2d; argument similar to Case 1).*

Due to the curvature in WW, industry data does not identify "true" compensating differentials because industry data discards important information on wages and risk within industries.

This example has a straightforward generalization to include several firms and industries. However, the quantitative importance of the bias due to aggregation remains to be examined empirically, because it depends on (i) the nature of preferences and technology (leading to nonlinearity), and (ii) the amount of within industry heterogeneity in job risk. The following section will discuss the extent of aggregation bias in a study on the value of health.

3 Illness and Injury risk in Austria

The empirical analysis is based on Austrian linked employer-employee data on occupational illnesses and injuries in the period from 1986 to 1991. This section first provides information on the dataset and some descriptive statistics on the effects of using aggregate information on risk. Then, we discuss the illness and injury insurance system in Austria. The section closes with background information on the Austrian labor market.

3.1 Data

The empirical analysis uses data on a 2 % random sample of linked employer-employee data in Austria in the period from 1986 to 1991. The key advantage of using this dataset is that the data contains information on all employees of a firm.[3] Based on this data, we calculate the incidence of illnesses and injuries specific to a firm. Workplace injuries and illnesses are a summary measure of job disamenities. Accidents happen more often in a situation of understaffing, when outdated tools and equipment are used to perform dangerous tasks, etc. Also, workers report sick more often if they are psychically distressed by conditions at the work place.

Second, we calculate information on the firm's age and gender structure, average tenure, and skill structure. Age and gender structure control for the differences in illness risk associated with age and gender. Average tenure and skill structure capture differences in average qualification level across firms and control for the differences in the length of full insurance by tenure and skill level mentioned above.

At the individual level, the data contains precise information on total compensation, and the usual demographic variables except education. The main disadvantages of the data are (i) the data do not contain information on hours, and (ii) earnings information is censored from above.[4] While censoring can easily be handled by the Tobit estimator, the fact that information on hours is missing appears critical. However, Austria enforces tight working time regulations.[5] Also, to deal with missing information on hours, we first excluded sectors most

[3]The data collection authority in Austria (Hauptverband der Österreichischen Sozialversicherungsträger) defines a firm as a center of production in one location. While we can not observe wether multiple firms belong to the same enterprise, our focus is to construct very detailed risk information. To this end, there is no need to aggregate firm into enterprises.

[4]The principal purpose of this data is to collect information for pension benefits. Because there is a maximum threshhold on pensions, wages exceeding the threshhold are censored. About 10 % of wages are above the threshhold.

[5]Normal weekly hours are limited to 40. Overtime hours can not exceed 10 per week. Workers are not allowed to work more than 9 hours per day on a regular basis.

likely to work irregular or non-normal hours (agriculture, education). Second, we excluded workers with very low earnings (more than 6 SD from mean) from the analysis.

Table 1 (first row) shows illness risk in the US and in Austria. The US risk variable is constructed according to the formula $R = (N/EH) * 200,000$, where N is number of injuries and illnesses with days away from work, EH is total hours worked by all employees during the calendar year, and $200,000$ is the base for 100 equivalent full-time workers (working 40 hours/week * 50 weeks / year * 100 workers). The Austrian risk measure is calculated differently because we do not have information on hours. The formula is $R = (N/D) * 22,500$, where N is the number of illness spells observed, D is the total number of days worked in the calender year, and 22,500 is the base for 100 full-time equivalent workers (working 5 days/week * 45 weeks/year * 100 workers).

Table 1

Table 1 demonstrates that the incidence of illnesses or injuries in Austria is comparable to the incidence of illnesses and injuries in the United States. In the United States 3.9 out of 100 workers did not report to work because of occupational illness or injury in 1986 to 1991. There were 7.0 lost workday cases in our sample in that period.

Section 2 points out that industry risk is likely to be a bad proxy for job risk if firms are heterogeneous within industries. This appears to be the case in our sample. Table 2 reports mean and variance of illness and injury incidence at the industry as well as at the firm level. While illness risk has a variance of 59.3, the variance of risk measured with aggregate data reduces to 16.8 (less than one third of "true" risk). The major part of the differences in jobs is due to heterogeneity within industries, not across industries.

Table 2

3.2 Insurance for Illnesses and Injuries

In case of illness or injury, Austrian workers are entitled to 100 % replacement of their wage by the employer for a minimum period of 4 weeks. The full insurance period increases with years of seniority to a maximum of 16 weeks (25 plus years of tenure). After the full insurance period has expired, workers are entitled to 50 % replacement of their wage for another 26 to 78 weeks (depending on the insurance company). Entitlement to full replacement of wages is renewed if a worker is not repeatedly ill or injured in the 6 months (12 months for blue collar workers) period after the end of a previous spell.

The data contains information on illness spells lasting longer than the full insurance period. While the disadvantage is that we do not have information on all injuries and illnesses, it appears fair to say that long spells of illness or injury capture important aspects of workplace hazards. Long spells are more likely to be caused by serious workplace disamenities than short spells.[6] Additionally, the exact nature of the risk variable is not central to the extent of bias resulting from aggregation, the principal subject of this study. As long as both, industry and firm risk, are based on the same data source, the extent of bias in compensating wage differentials can still be examined empirically.

3.3 The Austrian Labor Market

Table 1 compares the Austrian labor market to the US labor market with respect to institutions and outcomes (based on Nickell and Layard, 1999). This is motivated by the fact that most studies on compensating differentials for risk were conducted using US data (see Viscusi, 1993).

Table 1 shows that *unions* are more important in Austria than in the United States. However, union density matters less than union coordination for wage flexibility (see Layard et al., 1991). Table 1 shows that union coordination is higher in Austria than in the United States.[7] Comparing the US and Austria on both measures of union influence, a new picture emerges. In the US, unions have low membership but they do not coordinate, resulting in not so flexible wages for the unionized part of the labor market. On the contrary, Austria has higher union density, but unions do coordinate, resulting in somewhat flexible wages.[8]

Given this difference in institutions, it is perhaps surprising that both labor markets *operate* in a similar manner (Table 1, bottom panel). We concentrate on employment outcomes to check the extent to which the Austrian labor market operates as pictured by the theory of equalizing differences. Austria's average *unemployment* rate in the period from 1983 until 1996 was lower

[6] In Austria, there is a heated debate on the fact that most short illnesses and injuries start on a Friday or Monday. Ruling out these short illness spells filters out "sick leaves" that are "sick holidays".

[7] Union coordination is a synthetic index that ranges from 1 (low) to 3 (high).

[8] Duncan et al. (1980) show that union wage differentials may compensate for unfavorable working conditions in the union sector. While it would be interesting to test for union wage differentials in Austria, this is not possible with the present dataset because it does not contain information on union membership.

than the corresponding US figure and much lower than the European average. With respect to labor inputs, the US has a 6 percentage point higher *employment to population* ratio than Austria. Labor *productivity* measured by GDP per worker is 13 percentage points higher in the United States than in Austria. However, GDP per hour worked is the same in both countries.

In sum, while there are important differences with respect to institutions, the Austrian labor market is comparable to the US labor market with respect to outcomes. Our analysis of compensating wage differentials is conducted in a labor market that is very similar to the labor market in a typical value of health study.

4 Compensation for illness or injury risk

This section discusses the magnitude of the bias due to the "aggregate approach" of measuring the value of health. First, cross-section results on the compensation for illness risk using industry data are reported. Then, we compare these result to results on compensation for illness risk based on data that acknowledges job differences within industries. Finally, a sensitivity analysis discusses the role of unobserved individual or job specific heterogeneity.

4.1 Cross section results

Table 3 Panel A reports results from a "hedonic wage" (Tobit) regression based on the aggregate methodology. This means that we regress the log of yearly total compensation on an *aggregate* measure of risk, here the incidence of illness risk across *industries*. In all estimates, we control for a number of individual characteristics that hold constant different risk preferences, observable job differences, and differences in risk due to age or gender.[9]

Table 3

Table 3 Panel A shows that high risk jobs pay better than low risk jobs. The coefficient on the risk variable is positive significant. According to estimate A, the hedonic wage function is linear, the coefficient on illness squared is insignificant. The interaction term between risk and tenure tests if workers with long tenure demand lower compensating differentials. Workers

[9] The characteristics we use are age, tenure (and its square), time trend, age when entering the labor market, male, firm size, industry effects (recall that we have time variation in the risk measure), share male, share white collar, share 40 to 65 (in industry, Panels A, and C; in firm, Panels B and D).

with long tenure are entitled to a longer full insurance period than workers with short tenure. The estimates show that this appears to be the case. The interaction term of risk with tenure is negative and significantly different from 0.

At the bottom of Table 3, we report what percentage of the median wage is due to risk in the average job. This risk differential is defined as $(p * \partial w/\partial p)/w$, where p is mean risk, $\partial w/\partial p$ is the marginal effect of risk on wages at the mean, and w is the mean wage.[10] The estimate indicates that 8.28 % of the mean wage in Austria is, in fact, compensation for risk. This figure is substantially higher than the fraction of wages explained by risk in the US of 4.92 % (see Hersch, 1998). This difference can probably be attributed to the fact that we use data on severe illnesses and injuries, whereas US data contains information on all illnesses and injuries.

How large can the bias from discarding information within industries get? Table 3 Panel B contains results from a hedonic wage regression that is *identical* to the hedonic wage regression in Panel A, except for the measure of risk used. In Panel B, we use illness risk based on information for each firm. The bias from the "aggregate approach" can be very large. While the point estimate of the effect of risk on wages is still positive and significant, it is halved from 0.0136 to 0.0064. The hedonic wage function in Panel B is concave implying that the marginal utiliy from income is lower in case of illness ($V' < U'$).[11] Recall that a nonlinear hedonic wage function gives rise to aggregations bias. Workers with longer seniority demand lower compensation for risk. The average individual would be willing to pay only 4.28 % of wages to reduce risk from the mean to 0. This is almost half the willingness to pay identified using industry data.

Can the difference between the estimates in Panel A and B be explained by measurement error? Recall that we observe all illness and injury spells that last at least as long as the full insurance period (Section 3). True firm illness risk is different from the risk measure we use leading to a downward bias in the estimated coefficients. When we use industry illness risk, however, there is another source of measurement error. We assign the wrong level of risk to workers that have a job that is either riskier or not as risky as the average job in the industry.

[10] Mean wage is estimated by using the fact that the uncensored log wage distribution is symmetric. In symmetric distributions, the mean equals the median. The median log wage is known in this sample, because less than 50 % of wages are censored.

[11] We experimented with higher order terms on illness. These were not significant.

As a consequence, one would expect that the compensating differential is *lower* using industry risk data. However, we find that the opposite is the case.

4.2 Fixed-effect estimates

Most of the value of health literature and the estimates in Panels A and B use cross-section methodology. There are two problems with this approach. First, Hwang et al. (1992) show that in a realistic example, the bias from unobserved heterogeneity may be substantial. The reason is that unobserved productivity may be correlated with job risk leading to an omitted variable bias. Second, Hanushek et al. (1996) show that aggregation alters the magnitude of omitted variable bias. Because we focus on differences between firm level vs aggregate level risk data, our results are prone to the critique in Hanushek et. al. (1996).

We deal with unobserved heterogeneity by exploiting time variation in risk and wages contained in the dataset. Usually, one removes unobserved individual effects by taking deviations from individual means. Here, this strategy does not work because wages are censored. However, Honoré (1992) shows that a semi-parametric approach to removing person fixed-effects is feasible.[12] The Honoré (1992) estimator is consistent, asymptotically normal, and there is no need for distributional assumptions on the error term.

Table 3 Panels C and D show that controlling for unobserved heterogeneity strengthens the conclusion based on cross section estimates. While the "aggregate approach" leads one to believe that individuals would give up 6.81 % of their income to avoid illness risk estimates based on firm data show that the willingness to pay amounts to 1.28 % of mean income.[13]

In sum, the "aggregate approach" of the value of health literature that uses aggregate risk information to proxy for job risks leads to larger estimates of the compensating differential for risk than an approach based on firm data on risk. This may be explained by the fact that both conditions for bias discussed in Section 2, nonlinear willingness to pay for risk and within

[12]The idea of the Honoré (1992) estimator is that if measurement error is identically distributed across two (or more) periods, the distribution of the dependent variable is symmetric conditional on the exogenous variables. This result does not depend on the presence of a fixed effect. The estimator chooses the coefficients such that a loss function penalizing departures from symmetry is minimized.

[13]It is interesting to note that indeed aggregation appears to alters the bias from unobserved heterogeneity as pointed out by Hanushek et al. (1996). The bias based on aggreaget data is about 1.5 percentage points (8.28-6.81 =1.47) , whereas the bias is 3.0 percentage points in firm data (4.28-1.28=3.0).

industry heterogeneity of jobs, are present in this sample.

5 Conclusions

The empirical literature concerned with estimating the value of risks to health or life has been successful in identifying large and positive wage differentials for risks. This literature uses predominantly industry average risk data to proxy for job risks. Under plausible circumstances, in particular, if industries consist of heterogenous firms, this may lead to a bias in the estimated value of health.

This paper illustrates this point with matched employer-employee data in Austria. Because we observe firm-specific risk as well as industry average risk, we can examine empirically how large the bias from using aggregate risk measures can get.

In this sample, the bias is substantial. The estimated compensation for risk is two to five times larger using aggregate measures of risk instead of precise information on job risk. The result is robust to controlling for time constant unobserved individual or job heterogeneity.

To the extent that firms differ within an industry, this finding may generalize. Previous studies that measured the value of risks to life and health may have overestimated the willingness to pay for a reduction of these risks. With the increasing availability of linked employer-employee data, further research should address the issue of ”putting a price on life and health” anew.

References

[1] Brown, Charles (1980). Equalizing Differences in the Labor Market. *Quarterly Journal of Economics* 94(1):113-34.

[2] Dickens, William T. and Lawrence F. Katz (1987). Inter-industry Wage Differences and Theories of Wage Determination. NBER Working Paper No. 2271. Cambridge: NBER.

[3] Dorman, Peter (1996). *Markets and Mortality: Economics, Dangerous Work, and the Value of Human Life*. Cambridge, UK: Cambridge University Press.

[4] Dorman, Peter and Paul Hagstrom (1998). Wage Compensation for Dangerous Work Revisited. *Industrial and Labor Relations Review* 52: 116-135.

[5] Duncan, Greg J. and Frank P. Stafford (1980). Do Union Members Receive Compensating Wage Differentials? *American Economic Review* 70(3): 355-371.

[6] Duncan, Greg J. and Bertil Holmlund (1983). Was Adam Smith Right after All? Another Test of the Theory of Compensating Wage Differentials. *Journal of Labor Economics* 1(4):366-79.

[7] Filer, Randall K. (1998). The Search for Compensating Differentials: Is there a Pot of Gold after all? mimeo. University of New York.

[8] Hanushek, Eric A., Rivkin, Steven G. and Lori L. Taylor (1996). Aggregation and the Estimated Effects of School Resources. *Review of Economics and Statistics* 78(4): 611-27.

[9] Hersch, Joni (1998). Compensating Differentials for Gender-Specific Job Injury Risks. *American Economic Review* 88(3):598-607.

[10] Honoré, Bo (1992). Trimmed LAD and Least Squares Estimation of Truncated and Censored Regression Models with Fixed-Effects. *Econometrica* 60: 533-565.

[11] Hwang, Hae-shin, Reed, Robert W. and Carlton Hubbard (1992). Compensating Wage Differentials and Unobserved Productivity. *Journal of Political Economy* 100(4): 835-58.

[12] Krueger, Alan B. and Lawrence H. Summers (1988). Efficiency Wages and the Inter-industry Wage Structure. *Econometrica* 56(2): 259-93.

[13] Layard, Richard, Nickell, Stephen and Richard Jackman (1991). *Unemployment: macroeconomic performance and the labour market*. Oxford: Oxford University Press.

[14] Leigh, Paul J. (1991). No Evidence on Compensating Wages for Occupational Fatalities. *Industrial Relations* 30: 382-395.

[15] Leigh, Paul J. (1995). Compensating Wages, Value of a Statistical Life, and Inter-Industry Differentials. *Journal of Environmental Economics and Management* 28: 83-97.

[16] Moore, Michael J and Kip W. Viscusi (1988). Doubling the Estimated Value of Life: Results Using New Occupational Fatality Data. *Journal of Policy Analysis and Management* 7(3): 476-90.

[17] Nickell, Stephen and Richard Layard (1999). Labor Market Institutions and Economic Performance. in *Handbook of Labor Economics* vol 3C, eds. Orley Ashenfelter and David Card. Amsterdam: North-Holland.

[18] OECD (1990). *Employment Outlook*. Paris: OECD.

[19] OECD (1994). *Employment Outlook*. Paris: OECD.

[20] Rosen, Sherwin (1986). The Theory of Equalizing Differences. in *Handbook of Labor Economics*. Eds: Orley Ashenfelter and Richard Layard. Amsterdam: North-Holland.

[21] Thaler, Richard and Sherwin Rosen (1976). The Value of Saving a Life: Evidence from the Market. in *Household production and consumption*. Ed.: Nestor E. Terleckyj. Cambridge: NBER.

[22] Viscusi, Kip W. (1993). The Value of Risks to Life and Health. *Journal of Economic Literature* 21:1912-1946.

Table 1. Comparing Austria to the United States

	United States	Austria
Incidence of injuries or illnesses[a], 1986-1991	3.9[b]	7.0[c]
Institutions		
Unions		
density	15.6	46.2
coordination	1	3
Outcomes		
Unemployment, 1983 - 1996	6.5	3.8
Emp. / Pop. , 1994-1996	73.1	67.3
Labor Productivity, 1994 (US=100)		
GDP / Worker	100	87
GDP / Hour	100	100

Notes: Source Nickell and Layard (1999), US Dept of Labor, own calculations.
a. (N/EH) x 200,000, where N is number of injuries and illnesses with days away from work, EH is total hours worked by all employees during the calendar year, and 200,000 is the base for 100 equivalent full-time workers.
b. All incidences with at least one workday lost.
c. All incidences with at least 4 weeks of workdays lost (see Section 3 for details).

Table 2. Occupational injury and illness risks, Firm vs Industry

	Mean	Variance
Risk measured at ...		
Industry level	7.0	16.8
Firm level	7.0	59.3
Deviations from industry mean	0.0	42.5
Number of industries	22	
Number of firms	261	

Notes: Source: own calculations. Definition of Incidence: see notes to Table 1

Table 3. Compensation for Illness Risk

	A	B	C	D
Risk measured at	Industry level	Firm level	Industry level	Firm level
Illness Risk	0.0136 **	0.0064 **	0.0119 **	0.0019 **
	(0.0040)	(0.0005)	(0.0018)	(0.0003)
Illness Sqared /1000	-0.2594	-0.0449 **	-0.3026 **	-0.0079 **
	(0.1720)	(0.0073)	(0.0653)	(0.0034)
Illness * Tenure / 1000	-0.0023 **	-0.4036 **	-0.001 **	-0.1823 **
	(0.0002)	(0.0403)	(0.0002)	(0.0248)
Individual fixed effects	No	No	Yes	Yes
Risk differential as % of mean wage[a]	8.28	4.28	6.81	1.28
US	4.92	-	-	-
Log likelihood	-14367.5	-14038.5		
Loss function			197.178	200.14
N	42432	42432	42432	42432

Note: Dependent variable: log(yearly compensation). Standard Errors in parentheses. *, ** indicate significance at the 10% (5%) level.
Tobit estimator, Panels A and B, and Honoré (1992) fixed effect estimator, Panels C and D. Other controls are share male, share white collar, share 40 to 65 year old in industry/firm, firm size, age, tenure, time trend, male, industry fixed effects.
a. (p*dw/dp)/w, where p is mean risk, dw/dp is the marginal effect at the mean, and w is mean wage. The US value is from Hersch (1998).

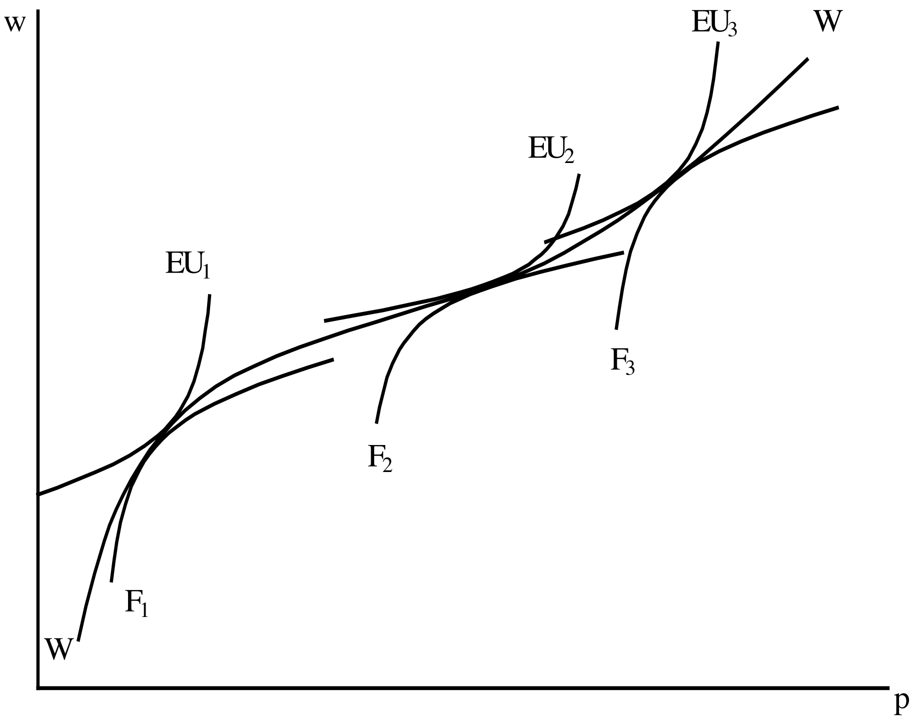
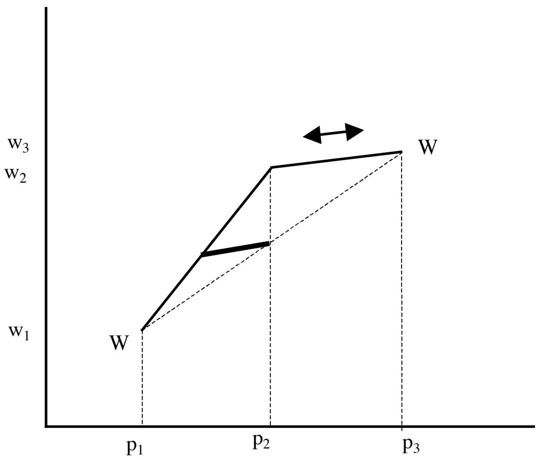


Figure 1. Equilibrium with three firms and three workers. F1, F2, and F3 are isoprofit lines, EU1, EU2, and EU3 are indifference curves.



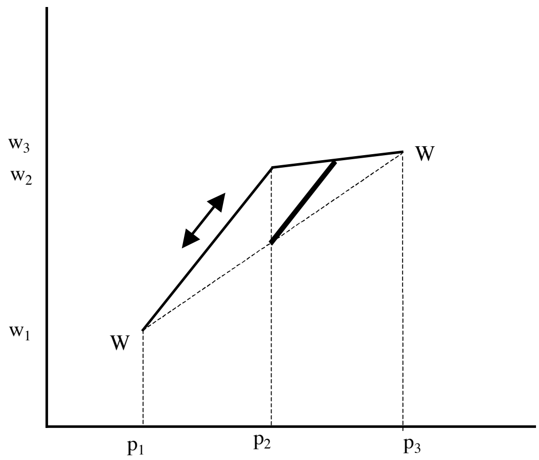
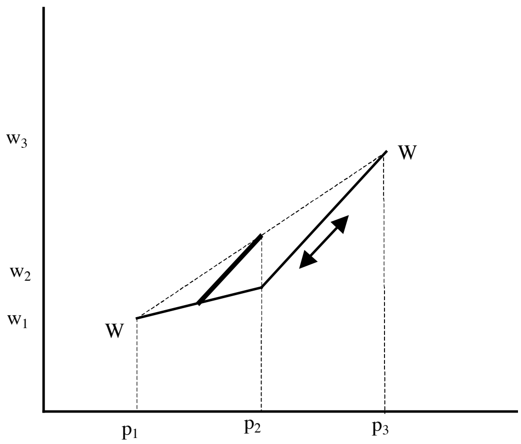


Figure 2a. Industry 1 low risk

Figure 2b. Industry 1 high risk

Concave hedonic wage function WW



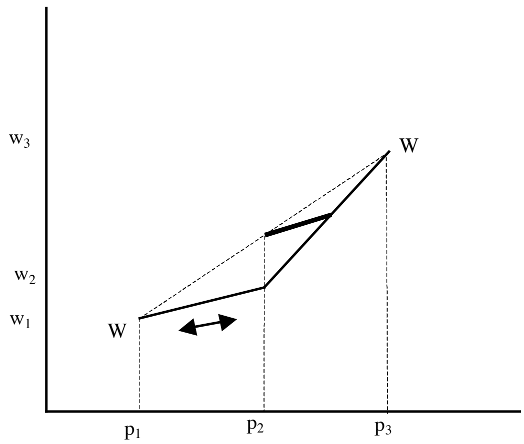


Figure 2c. Industry 1 low risk

Figure 2d. Industry 1 high risk

Convex hedonic wage function WW

Note: Firm 1 and firm 3 belong to industry 1, firm 2 belongs to industry 2 (consisting of just this firm). The fat ray is the locus of industry 1 risk. The industry risk differential is the slope from a line starting on the fat ray, going through (w_2, p_2)